

Rebuttal Report

Principal Components Analysis of Geochemical Data from the Illinois River Watershed Northwest Arkansas and Eastern Oklahoma


Prepared for:

Tyson Foods, Inc.
Tyson Poultry, Inc.
Tyson Chicken, Inc.
Cobb-Vantress, Inc.
Cal-Maine Foods, Inc.
Cal-Maine Farms, Inc.
Cargill, Inc.
Cargill Turkey Production, LLC
George's, Inc.
George's Farms, Inc.
Peterson Farms, Inc.
Simmons Foods, Inc.
Willow Brook Farms, Inc.

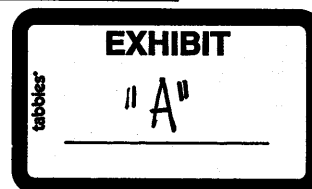
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1.0 Introduction and Overview

This report provides a critical review and rebuttal to the opinions of Dr. Roger L. Olsen of CDM Companies, Inc. (Olsen, 2008a), as well as a reanalysis of the data upon which his opinions are based. The issue in dispute is the degree to which a series of principal components analysis (PCA) runs conducted by Olsen, support his conclusions with regard to sources of phosphorus, bacteria and other constituents in the Illinois River Watershed in Northwest Arkansas and Eastern Oklahoma. A map of the study area is shown as Figure 1-1.

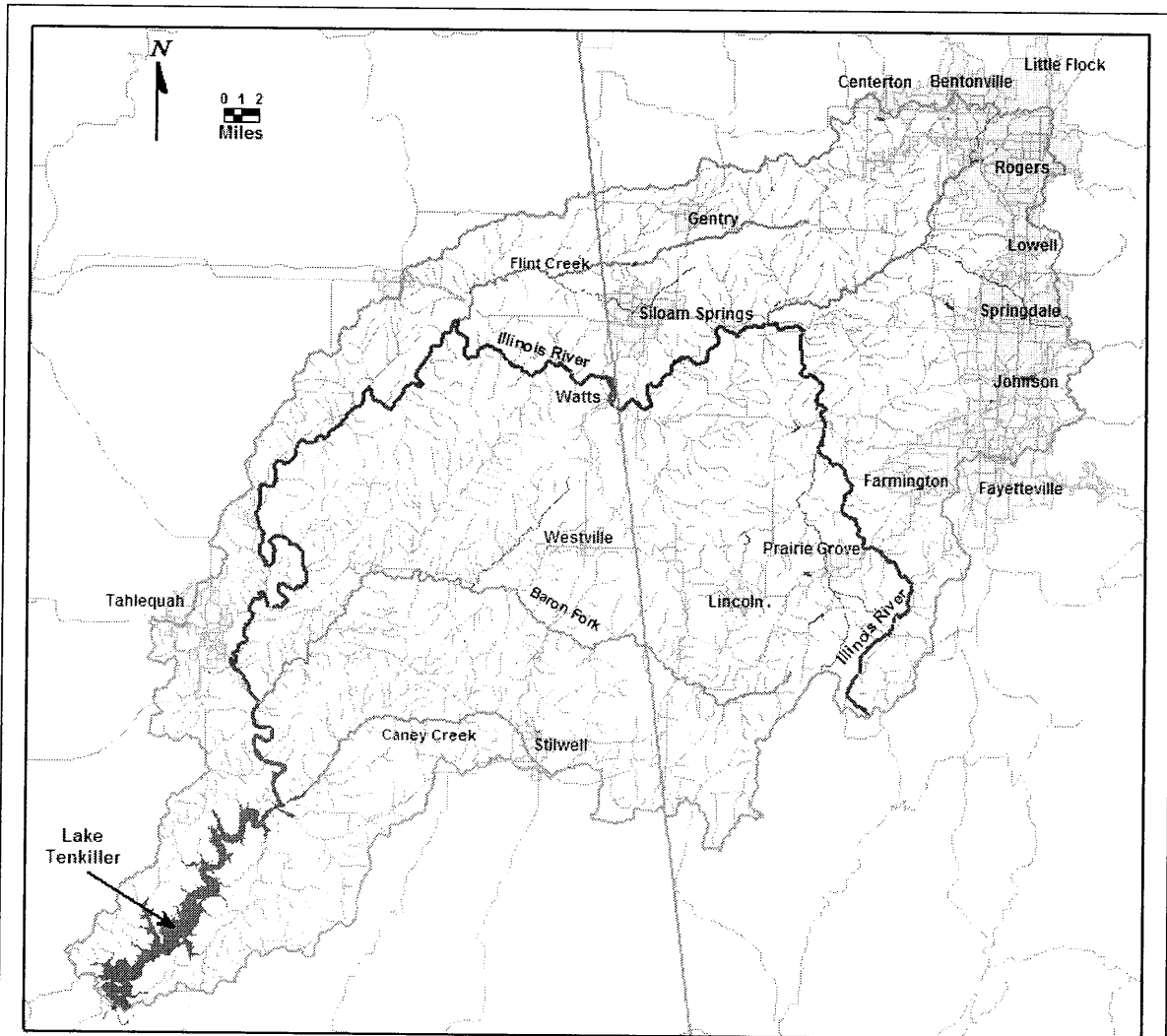


Figure 1-1. Site map showing rivers, creeks, lakes and cities/towns.
Gray shaded areas indicate regions of human population density > 400 people/mi², based on ESRI (2006) data.

Olsen's primary opinion based on his PCA, is summarized at the beginning of his report, in the following quote:

*"Principal components analysis (PCA) identified two major sources of contamination in the IRW: poultry waste disposal and WWTP discharges. Poultry waste is by far the dominant contamination source in the IRW when compared to other sources. Cattle waste contamination was unique from both poultry waste and WWTP effluent, and was identified in some samples with documented cattle manure contamination. However, chemical contamination from cattle waste is not dominant in the basin and only represents a minor source. In the PCA, the chemical and bacterial composition of poultry waste creates a distinct chemical signature that contains both phosphorous and bacteria."*¹

Olsen supports his application of PCA to IRW data sets by citing a number of papers in the literature where PCA and related methods were applied to environmental chemical data. There are indeed, many PCA applications in the literature. I have published such papers myself.² Olsen has not.³ I have also served as a peer-reviewer for PCA case-study papers submitted to a number of journals.⁴ There are numerous pitfalls for the unwary and/or inexperienced PCA practitioner. The mere existence of the literature cited by Olsen does not validate his work, nor does it give him license to err in PCA implementation, to misinterpret the results or to conceal lines of evidence that contradict his opinion. In this report, I will show that Olsen did all of this, and that his PCA does not identify sources of contamination in the IRW. Rather, it reflects the degree to which a small handful of chemicals exhibit a preference to be in solution, or to be associated with the particles in the suspended solids phase.

1.1 Qualifications

The conclusions and opinions in this report are based on my professional experience and education, and my opinions are supported to a reasonable degree of scientific certainty. My expertise is in the area of environmental forensics, with a particular focus on the application of multivariate statistical methods (including PCA) to environmental geochemical data. I received my M.S. in Geology at the University of Delaware in 1988 and my thesis focused on multivariate statistical analysis applied to geological data. I spent seven years in environmental consulting with Roux Associates, Inc. (West Deptford, New Jersey) and McLaren/Hart Environmental Engineering, Corp (Philadelphia, PA). During that time, I worked on a number of environmental contamination projects under a variety of regulatory authorities, including CERCLA, RCRA and a number of State regulatory authorities. I received my Ph.D. in Geological Sciences from the University of South Carolina in 1997, and my dissertation concerned development and application of a PCA based receptor modeling method to environmental geochemical data. Since 1995, I have been a research faculty member at the Energy & Geoscience Institute (EGI), Department of Civil and Environmental Engineering at the University of Utah. My current position is Research Associate Professor. My research at EGI focuses on development and deployment of multivariate statistical methods in geology, environmental chemistry, and environmental forensics. My environmental forensics work has focused on sources, fate and

¹ Olsen (2008a), p. 1-2. Bullet 3.

² Johnson, et al., 2007; Magar, et al., 2005; DeCaprio, et al., 2005; Johnson and Ehrlich, 2002; Johnson, 2002; Johnson, et al., 2000; Jarman, et al., 1997; Dore, et al., 1996; Ehrlich, et al., 1994.

³ See Olsen 9/11/08 Deposition, p. 306. Lines 2-8.

⁴ See Johnson CV: Appendix B, p. 14.

Going through the same process for the left trend (blue squares – samples 6 through 10 on Figure 4-5), the bar-graphs for these samples are shown on Figure 4-9. Again, the bacteria data exhibit a wide range of variability, with the highest values observed in otherwise low concentration samples, where missing data has been substituted.

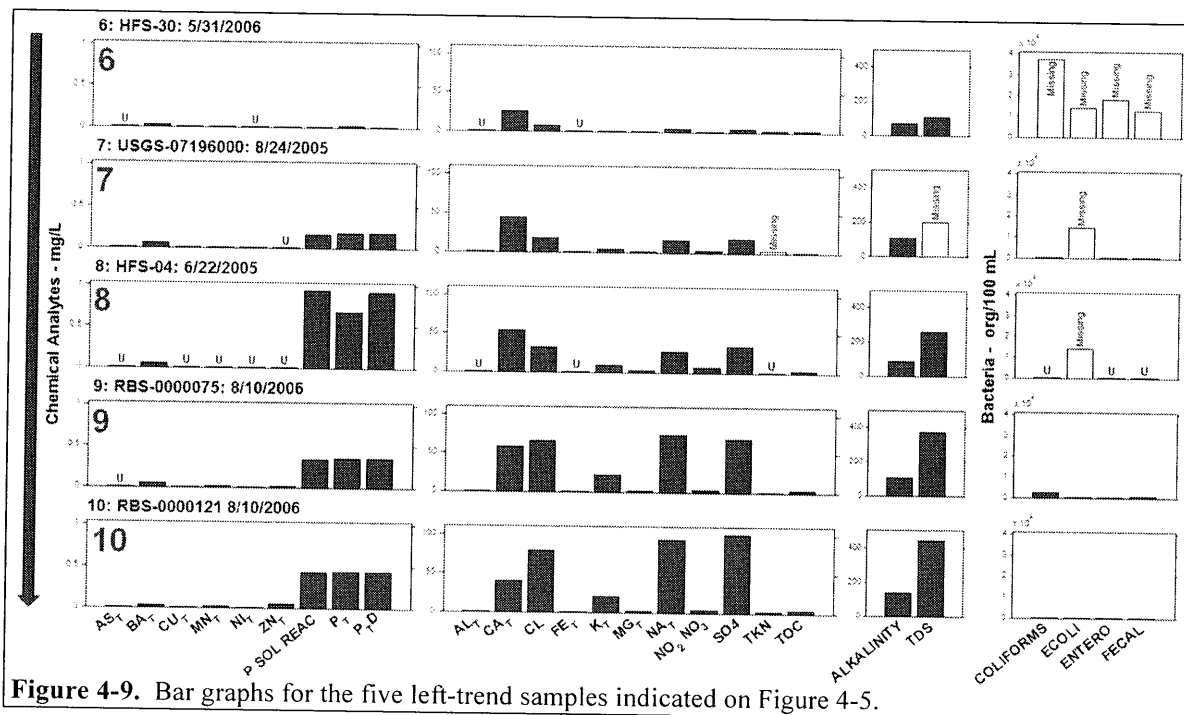


Figure 4-9. Bar graphs for the five left-trend samples indicated on Figure 4-5.

Variables shown with blue shading (total sodium (NA_T), total potassium (K_T), chloride (CL) and sulfate (SO_4)) all increase in concentration along this trend. These analytes are more soluble in water (Freeze and Cherry, 1979) so in contrast to iron and aluminum, they prefer to be in dissolved-phase rather than adsorbed to particulates. Once again, this should come as no surprise, and Olsen testified that for highly soluble analytes like sodium and potassium, the concentration reported as “total” should roughly equal their reported “dissolved” concentrations, because they are typically found entirely in solution.¹¹⁹

Note that all of these samples have low iron, aluminum and TSS (Figure 4-5 and 4-8). Note also that the two soluble forms of phosphorus (P_{TD} and P_{SOL_REAC}) are close to equal in each sample and are also close to the reported concentrations of total phosphorus. This suggests that the general increase in P concentrations in these samples (sample 8 being the exception) reflects dissolved phase phosphorus, rather than particle-bound phosphorus.

As for the bottom trend, I picked just five samples to show on Figure 4-9. Figure 4-10 shows Olsen’s SW3 scores plot, with the symbol color keyed to the concentration of $NA_T + K_T + Cl + SO_4$. The trend observed in the bar-graphs above, is evident for the data set as a whole. The concentration of highly soluble analytes increases as you move up along the left trend of Olsen’s SW3 scores plot. Clearly, the primary controls on Olsen’s PCA are related to elementary geochemistry: whether an analyte is preferentially associated with the dissolved phase or particulate/suspended solids phase. To the extent Olsen’s PCA model reflects real-world geochemistry, it is controlled by solution/adsorption processes, not sources.

¹¹⁹ Olsen (2008a). p. 3-18. 4th paragraph. Olsen Deposition. 9/10/08. p. 116-117.